The Shape of Electrons in Liquid Helium

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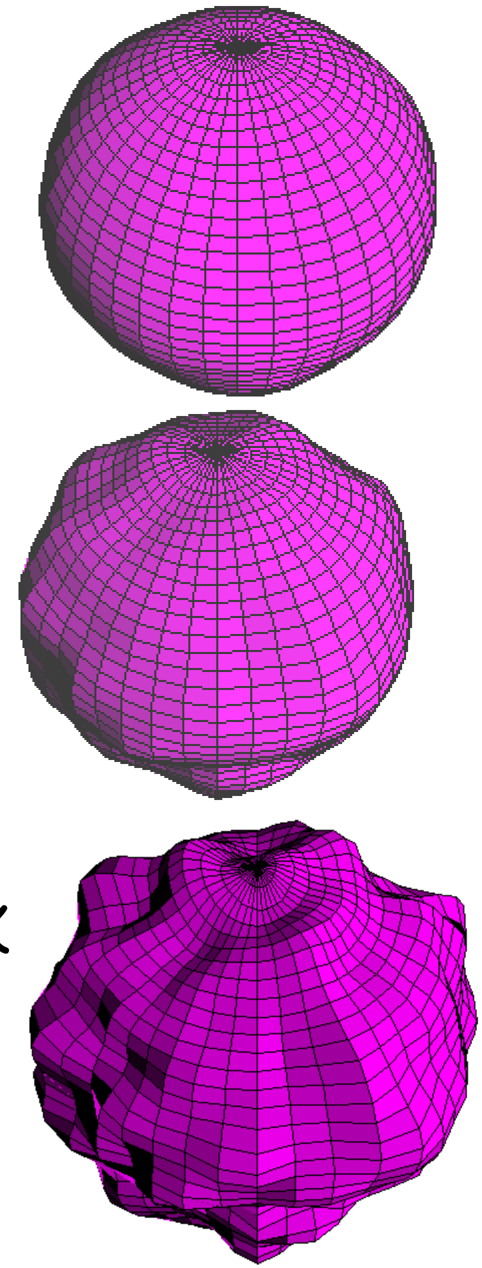
- Electrons repel helium atoms
- Electrons introduced into liquid helium form bubbles of diameter one millionth of an inch (= 4 nm).
- The shape of these bubbles fluctuates due to thermal vibrations and quantum fluctuations.



T=1 K

T=2 K

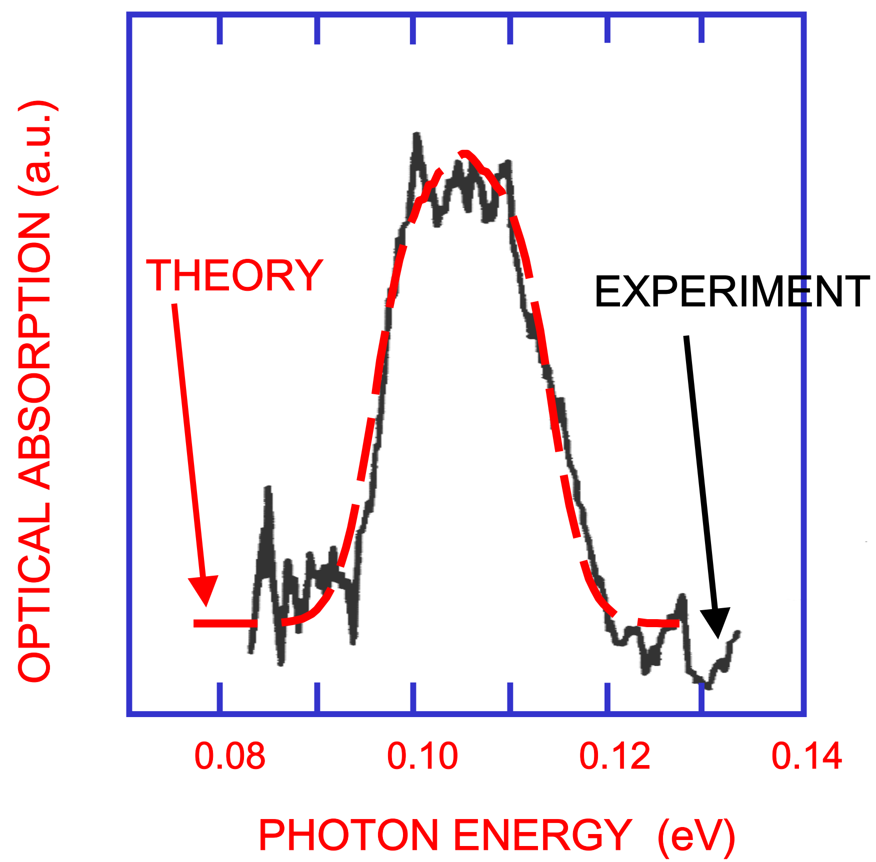
T=3 K

At the present time, many scientists are actively working to produce and study nanostructures. A nanostructure is an object that has dimensions less than or up to about one millionth of an inch. A cube with side one millionth of an inch contains approximately one million atoms. Most studies of nanostructures have been concerned with solid structures that have been built using techniques similar to those used in the fabrication of computer chips. Efforts have also been made to develop so-called "self-assembly" techniques for the fabrication of nanostructures. In this approach, an environment is established such that a nanostructure grows spontaneously into the desired form. Electron bubbles in liquid helium are an example of this type of process. When an electron enters liquid helium, it repels the helium atoms and forces open a bubble in the liquid. This bubble has a diameter of one millionth of an inch and at very low temperatures is perfectly spherical.

We are trying to learn more about these structures. Our investigations include studies of how the bubbles move through the liquid, how they are affected by light, and how they respond when subjected to pressure. Recently, we have calculated how the shape of a bubble changes when the temperature is raised. The thermal motion of the surrounding liquid causes the shape of the bubble to vary with time and as the temperature increases, the amplitude of these shape fluctuations increases. Although it has not yet been possible to take photographs to see the shape of a bubble, we are able to test our calculations in other ways. The fluctuations in the bubble shape modify the way that light is absorbed. We have been able to show that this change is in excellent agreement with the measurements of light absorption.

In the experiments performed so far, measurements have been made on a group of bubbles inside the liquid. In the future, we want to develop methods that make it possible to study the behavior of a single bubble. For example, we want to be able to observe an individual bubble as it moves through the liquid, to see how it is affected by other nearby objects and by electric fields.

- Calculated shape of the bubbles can be tested through measurements of the optical absorption. We have achieved excellent agreement between theory and experiment. Details will appear in an article in the Journal of Low Temperature Physics



BROADER GOAL

Develop ability to detect and manipulate single electrons.

EDUCATION and OUTREACH

Four graduate students contributed to this research. We have presented many colloquia and seminars on this research area and over the past five years there have been several articles in newspapers and science magazines about our work.